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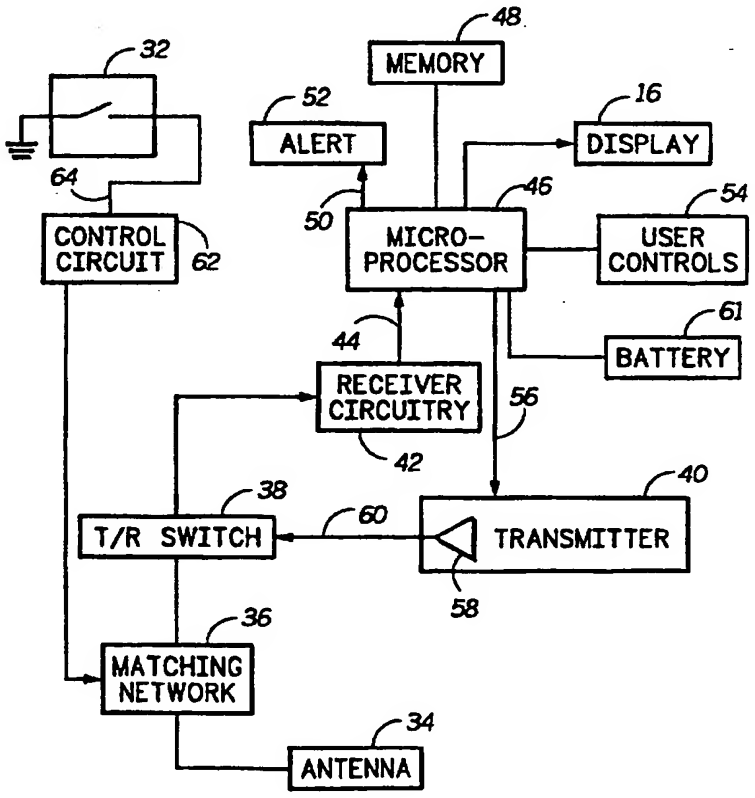
(54) Title: SELECTIVE CALL RECEIVER HAVING AUTOMATICALLY ADJUSTED IMPEDANCE MATCH FOR ANTENNA

(57) Abstract

A selective call receiver (10) has a base unit (12), a moveable cover (18), and an antenna (34). Within the base unit (12), an adjustable impedance matching network (36) is provided between the antenna (34) and receiver circuitry (42). When the cover is closed, the network (36) provides a predetermined impedance which compliments the body effect of the user to provide maximum power transfer between the antenna (34) and the receiver circuitry (42). When the user opens the cover (18), a switch (32) is activated to cause a control circuit (62) to develop a control signal that is applied to the matching network (36) for causing the matching network (36) to adjust its impedance to compensate for the assumed loss of the body effect.



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SELECTIVE CALL RECEIVER HAVING AUTOMATICALLY ADJUSTED IMPEDANCE MATCH FOR ANTENNA

Field of the Invention

This invention is directed generally to the field of selective call receivers that receive and/or send messages via RF; it is particularly directed to the provision of proper impedance matching for antennas used with such receivers.

Background of the Invention

Selective call receivers of the type under consideration employ a built-in antenna to receive and/or send messages. A pager is a primary example of such a receiver.

Pagers are typically intended to be carried "on body", as by clipping it on the user's belt or carrying it in a pocket. Because of the well know body effect which influences the tuning of the pager's antenna, the antenna is designed and tuned to compliment the body effect. The net effect is a pager with optimized power transfer between the pager's antenna and its receiver circuitry. When the pager is "off body", i.e. not in close proximity to the user's body, the body effect is lost and the power transfer between the pager's antenna and its receiver circuits is severely reduced. Stated differently, the pager will typically experience a return loss less than 10db when the pager is not in close proximity to the user's body.

Certain pagers and other forms of personal communication devices are designed to be used "on body" and "off body". For example, a pager that is designed to transmit

as well as to receive may be normally in the receive mode when "on body", but will be removed from close proximity to the user's body when the user desires to review a displayed message or to send a response. With circumstances such as these, it is desirable to automatically compensate for the loss of the body effect when the pager is "off body" in order to maintain a maximum power transfer to and from the pager's antenna.

Brief Description of the Figures

FIG. 1 is a perspective view of a selective call receiver according to the invention;

FIG. 2 is a graph of antenna return loss for the purpose of explaining the usefulness of the invention;

FIG. 3 is a block diagram of a preferred embodiment of the invention; and

FIG. 4 is an electrical schematic diagram showing more detail of the impedance matching network and the control circuit shown in FIG. 3.

Description of the Preferred Embodiment

Referring to FIG. 1, a selective call receiver 10 is shown that is constructed in accordance with the invention. The illustrated receiver 10 is a two-way pager having a base unit 12 which houses a receiver, transmitter and other circuitry that is described later. Mounted on the base unit are various user controls 14 and 15 by which the user can display messages, delete messages, etc. An LCD display 16 displays messages received by the selective call receiver.

Attached to the base unit 12 is a cover 18. This cover, shown in an open position, may be attached to the base unit 12 via a spring-biased hinge (not shown) at 20. The user may close the cover by manually rotating the cover 18 downward (as shown by arrow 22) against the bias of the hinge until the cover is flush against the upper surface 24 of the base unit 12. In this closed position, the cover 18 covers the display 16 and the user controls 14.

When the receiver 10 is in the receive mode, the cover 18 is normally closed and the receiver is carried on the user's body, such as being clipped to the user's belt or carried in a pocket of the user's clothing. As explained previously, the receiver's close proximity to the user's body brings into play the body effect which influences the tuning of the receiver's antenna. The illustrated receiver 10, and conventional selective call receivers, are designed to take advantage of the body effect. For conventional receivers, best reception occurs when the receiver 10 is in close proximity to the user's body. When the receiver is removed from the body, the absence of the body effect results in poorer reception of transmitted RF signals unless the receiver compensates for the loss of the body effect. The illustrated receiver 10 is adapted to achieve such compensation.

Referring to FIG. 2, the results of body effect are shown in terms of antenna return loss. The illustrated graphs apply to a selective call receiver that is designed to receive signals at about 283 MHZ.

When the selective call receiver is in close proximity to the user's body, the curve 26 is applicable. It shows an

antenna return loss of approximately-33db at 283 MHz. When the same receiver is moved "off body", the center frequency is reduced to about 280 MMz and the return loss is reduced to about -17db. This can result in significantly degraded reception when the selective call receiver is "off body".

In the case of a selective call receiver that can also transmit (a transceiver), such a receiver would normally be worn "on body" when in the receive mode, in which case the superior reception illustrated by the curve 26 would occur. To transmit, a user may remove the transceiver from its "on body" position and hold it in his hands to use one of the user controls to activate a transmission. In that circumstance, the transceiver would be operating with the undesirable return loss illustrated by the curve 28, unless some form a compensation is provided for the loss of the body effect.

A selective call receiver according to the invention may operate in a receive-only mode, or may be a transceiver that receives incoming messages and automatically transmits an acknowledgment signal. Instead of, or in addition to automatically transmitting an acknowledgment signal, a selective call receiver according to the invention may have the capability of transmitting a message under user control. In any case, a selective call receiver according to the invention does, under normal usage, maintain the superior antenna return loss characteristic as shown by the graph 26, irrespective of whether the receiver is "on body" or "off body".

To achieve this result, the selective call receiver 10 makes use of the cover 18 to determine whether the unit is

"on body" or "off body". When the cover 18 is in its closed position, (the normal receive mode), it is assumed that the receiver 10 is "on body". This is the position the cover would normally be in when worn in the user's pocket or clipped to a belt.

A switch-actuator, shown in the form of a spring-biased button 30, is mounted on the front surface 24 of the receiver 10. When the cover is closed, the cover engages the button 30 and urges it downwardly to close a cover switch 32 (see FIG. 3) that is mounted within the base unit 12. Closure of this switch indicates that the cover is closed, and the assumption is made that the receiver 10 is "on body". In that condition, the receiver 10 is operating per the graph 26 (FIG. 2) because the receiver is designed to use the body effect to achieve maximum power transfer to and from the receiver's antenna.

When the cover 18 is opened by the user to read a message or to send a message, the cover disengages from the button 30, thereby allowing the switch 32 (FIG. 3) to move to the opposite position. This indicates that the receiver 10 is likely in an off-body position, whereupon the new position of the switch 32 is used as a signal to compensate for the loss of the body effect.

Referring to FIG. 3, this figures shows an electrical block diagram of the selective call receiver 10 in accordance with a preferred embodiment of the invention. The illustrated embodiment includes an antenna 34 for intercepting transmitted radio signals and for transmitting radio signals originating at the selective call receiver. The antenna 34 is coupled to an impedance matching network 36 (described

more fully below) which is coupled through a conventional transmit/receive (T/R) switch 38 to a transmitter 40 and to receiver circuitry 42.

Referring first to the receiver circuitry 42, it may be a conventional four-level FSK FM and analog SSB AM receiver. The signals coupled to the receiver circuitry by the T/R switch 38 are preferably selective call (paging) signals which provide, for example, a receiver address and an associated message. The receiver circuitry 42 processes the received signals and produces demodulated information that is coupled via lead 44 to one input of a microprocessor 46. The microprocessor 46 may be conventionally programmed to process the information supplied by the receiver circuitry 42. For example, the microprocessor compares a received address with one or more selective call addresses stored in a memory 48. When a match is detected, an alerting signal is generated and sent via a lead 50 to a conventional audible or tactile alerting device 52 for generating an audible or tactile call alerting signal to alert the user that a message has been received. Conventional user controls 54 (corresponding to user controls 14 or 15 in FIG. 1) allow a user to, among other things, select between an audible call alerting signal or a tactile call alerting signal in a manner well know in the art. The user controls 54 may also allow the user to select which received message he wishes to be shown on the display 16 for immediate reading.

Referring to the transmitter 40, it is coupled to the microprocessor 46 via a lead 56 to receive messages, possibly stored in the memory 48, for transmission. Such a message may be, for example, an acknowledgment that a message

intended for this selective call receiver has been properly received.

The transmitter typically includes a power amplifier stage 58. The output of the power ampler amplifier stage is coupled via a lead 60 to the T/R switch 38, and from there to the matching network 36 and then to the antenna 34.

A battery 61 is provided to supply power to the microprocessor 46 and to other elements of the selective call receiver in a conventional manner.

Referring to the matching network 36, it is selected to provide maximum power transfer between the antenna 34 and the receiver circuitry 42, as well as between the antenna and the transmitter 40. When the cover 18 is in the closed position ("on body" condition assumed), a fixed group of circuit elements within the matching network cooperate with the body effect to provide the return loss characteristic shown by the graph 26 (FIG. 2). When the cover is open, the matching network responds to a control signal so as to adjust the impedance between the receiver circuitry 42 (or the transmitter 40) and the antenna 34 to maintain the same return loss characteristics.

To sense the position of the cover 18 and to generate the control signal mentioned above, the selective call receiver includes the cover switch 32 and a control circuit 62. With the cover closed, the switch 32 is open, decoupling ground level from a lead 64 that couples the cover switch to the control circuit 62. In response, the control circuit remains

inactive (no control signal generated), and the matching network 36 maintains its on-body state.

When the cover is opened, the cover switch 32 closes in response to a release of pressure on the button 30 (FIG. 1). This forces the lead 64 to ground level and causes the control circuit 62 to generate a control signal which is applied to the matching network 36. In response, the matching network adjusts the impedance between the antenna 34 and the receiver 42 (or the transmitter 40) to maximize power transfer to/from the antenna.

A preferred embodiment of the control circuit 62 and the matching network 36 is shown in FIG. 4. The matching network has an input 66 that couples to the T/R switch 38. In the other direction, the input 66 couples to a fixed network comprising capacitors 68 and 70 and an inductor 72. This fixed network is selected to cooperate with the body effect so as to give maximum power transfer to/from the antenna 34 when the cover 18 is closed.

Coupled in parallel with the fixed network is an additional electrical component (capacitor 74) and a pin diode 76, the latter element receiving the control signal from the control circuit 62 via a RF choke 78. The pin diode becomes conductive upon receipt of the control signal to place the capacitor 74 in circuit with the fixed network. Thus, the impedance of the matching network is adjusted to compensate for the assumed loss of the body effect.

Turning now to the control circuit 62, it includes a NPN transistor 80 whose emitter is coupled to the cover switch 32.

The base and collector of this transistor are coupled through resistors 82 and 84 to the battery supply (B+).

A PNP transistor 86 has its base connected to the collector of transistor 80, its emitter coupled to the battery supply, and its collector coupled through a resistor 88 to the coil 78. With this arrangement, closure of the cover switch 32 causes the transistor 80 to conduct, thereby lowering the voltage at its collector. In response, the transistor 80 also conducts, thereby injecting current into the pin diode 76 via the resistor 88 and the coil 78. As a result, the pin diode conducts and essentially couples the capacitor 74 to ground level and places the capacitor 74 in parallel with the fixed network (elements 68-72).

This adjustment to the impedance of the matching network 36 results in power transfer to/from the antenna 34 remaining substantially constant and maximized, irrespective of whether the selective call receiver is "on body" or "off body".

Although the invention has been described in terms of a preferred embodiment, it will be obvious to those skilled in the art that various alterations may be made without departing from the invention. For example, the details of the control circuit 62 may be varied to suit a particular application. Likewise, the cover switch 32 and its activating button 30 may be replaced by a hall-effect or other type of sensor capable of sensing the opening of the cover.

Another contemplated variation involves eliminating the illustrated control circuit 62 and programming the

microprocessor 46 to instruct a voltage source to change its output voltage when the cover 18 is opened. The output of the voltage source would be coupled to a varactor that is coupled in parallel with the fixed elements of the matching network (replacing the pin diode 76 and the capacitor 74). Thus, the capacitance of the varactor would be changed in response to opening/closing of the cover, achieving substantially the same result as the illustrated embodiment.

Various other alterations and variations will be obvious to those skilled in the art in view of this disclosure. Accordingly, all such alterations and variations are contemplated as being within the spirit and scope of the invention as defined by the appended claims.

CLAIMS

1. A selective call receiver, comprising:

a base unit;

receiver circuitry housed in the base unit;

an antenna;

an impedance matching network coupled between the receiver circuitry and the antenna for providing an adjustable impedance;

a cover for the base unit, the cover being moveable between a first position and a second position; and

means for sensing a position of the cover and for generating a control signal responsive to the cover being in the first position,

the impedance matching network being responsive to the control signal for adjusting the adjustable impedance.

2. A selective call receiver as set forth in claim 1 wherein the cover's first and second positions correspond to open and closed positions, respectively, and wherein the impedance matching network responds to the control signal by changing its adjustable impedance so as to maximize the antenna's power transfer when the cover is in the open position.

3. A selective call receiver as set forth in claim 1 wherein said means for sensing the position of the cover includes a switch that is activated by movement of the cover.

4. A selective call receiver as set forth in claim 1 wherein the impedance matching network includes a fixed

network coupled in parallel with at least one additional electrical component and a pin diode that receives the control signal, wherein the pin diode becomes conductive upon receipt of the control signal to place the additional electrical component in circuit with the fixed network.

5. A selective call receiver as set forth in claim 1 further including a transmitter and a transmit/receive switch, wherein the transmitter and the receiver circuitry are both coupled to the transmit/receive switch and the impedance matching network is coupled between the antenna and the transmit/receive switch.

6. A selective call receiver, comprising:

a base unit,

receiver circuitry housed in the base unit and having an input;

a transmitter housed in the base unit and having an output;

a transmit/receive switch coupled to the receiver circuitry's input and to the transmitter's output, and having an output;

an antenna;

an impedance matching network coupled between the transmit/receive switch and the antenna for providing an adjustable impedance;

a cover for the base unit, the cover being moveable between a closed position and an open position;

a cover switch coupled to the base unit and adapted to be activated in response to the cover being in the open position; and

a control circuit responsive to actuation of the cover switch for developing a control signal for application to the impedance matching network,

the impedance matching network being responsive to the control signal for adjusting its impedance.

7. A selective call receiver as set forth in claim 6 wherein the impedance matching network includes a fixed network coupled in parallel with at least one additional component and a pin diode that receives the control signal, and wherein the pin diode becomes conductive upon receipt of the control signal to place the additional electrical component in circuit with the fixed network.

8. A selective call receiver as set forth in claim 7 wherein the additional component is selected to maximize power transfer to and from the antenna when the pin diode is conductive.

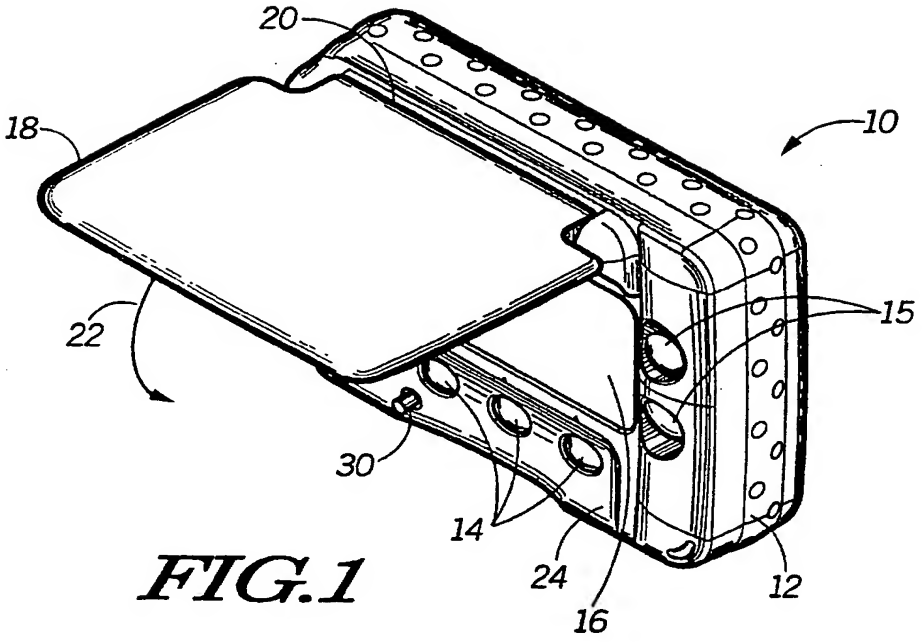
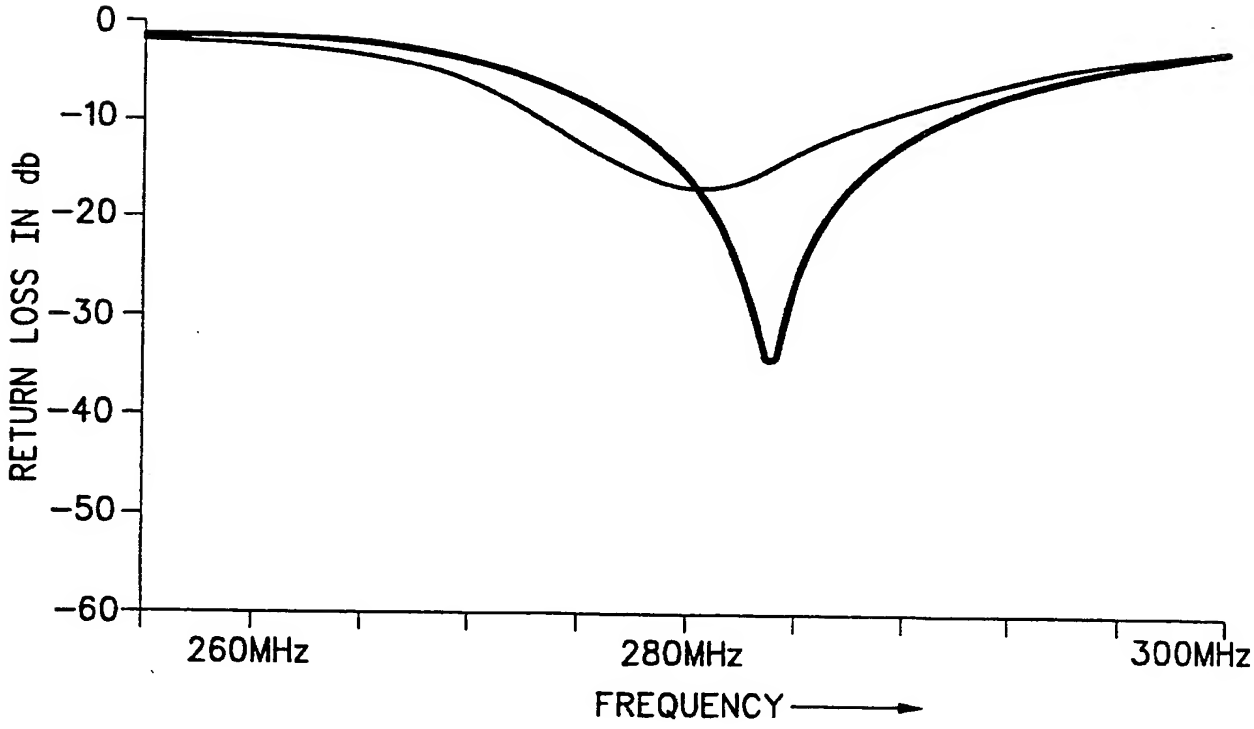

20
18
10
22
15
30
14
24
16
12

FIG.1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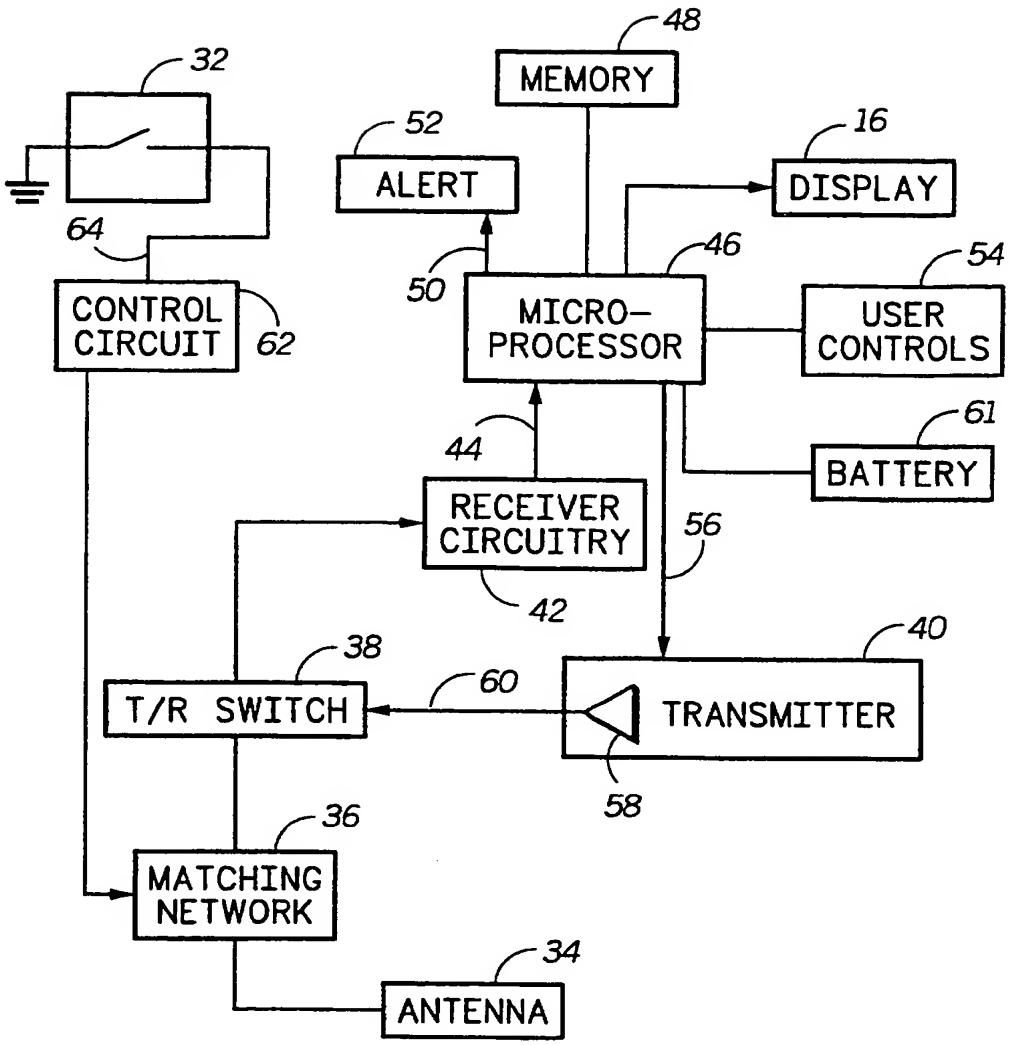
-10
-20
-30
-40
-50
-60
RETURN LOSS IN db
260MHz
280MHz
300MHz
FREQUENCY

FIG.2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MEMORY
32
52
ALERT
16
DISPLAY
64
50
46
54
CONTROL CIRCUIT
62
MICRO-PROCESSOR
USER CONTROLS
61
44
BATTERY
RECEIVER CIRCUITRY
56
42
40
38
60
T/R SWITCH
TRANSMITTER
58
36
MATCHING NETWORK
34
ANTENNA

FIG. 3

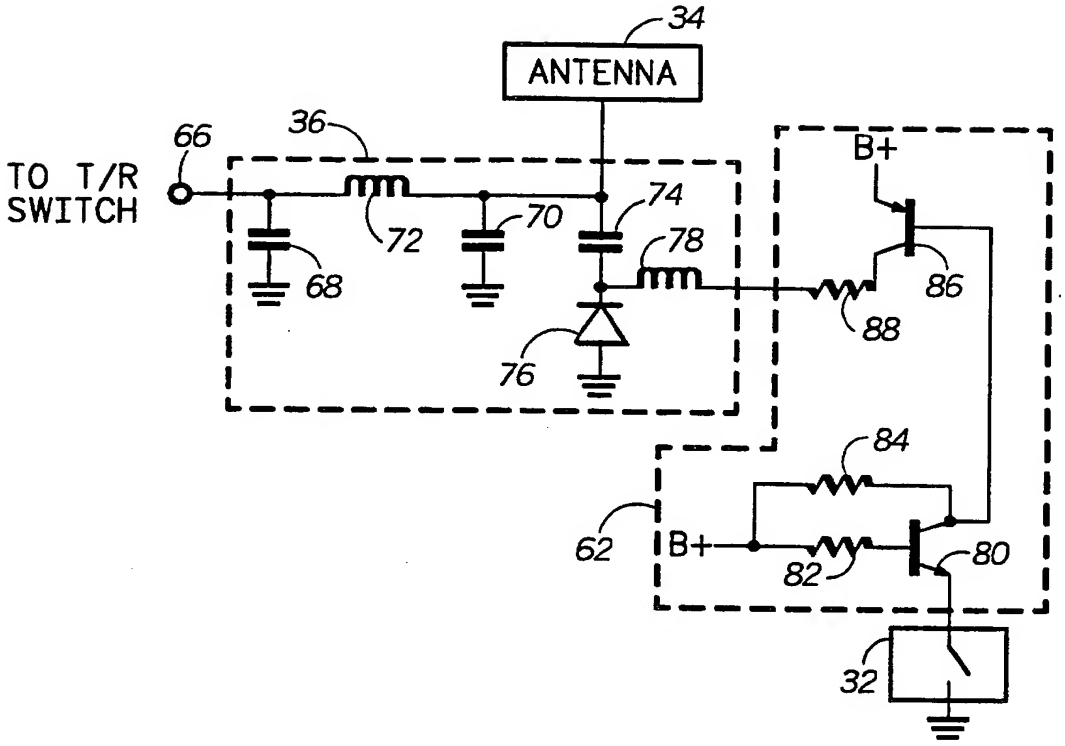

FIG.4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/04207

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H04B 01/18
US CL :455/289
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 455/289, 89, 90, 78, 38.1, 125, 74; 343/702, 860, 861

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS
search terms: antenna, impedance, switch, control, cover, flip, flap, matching, diode, parallel, pin diode

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US, A, 5,335,368 (Tamura) 02 August 1994, figures 1,3, col 3, lines 30-39, 50-55.	1-3 ---- 4-8
Y	US, A, 5,319,798 (Watanabe) 07 June 1994, figure 1.	5-8
Y	US, A, 5,361,403 (Dent) 01 November 1994, figure 3, col 5, lines 22-34.	4,7,8

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search 29 MAY 1996	Date of mailing of the international search report 10.06.96
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